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BACKSCATTERING ENHANCEMENT FROM ROUGH SURFACES

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Abstract

Several classical theoretical developments are available to treat rough surface scattering, each with a limited parameter domain of validity. Recent experimental work uses manufactured surfaces whose parameters (height and slope) are outside these domains. Predictions include an enhancement of the scattering in the backscatter directions for random surfaces of large *rms* height and slope. New methods to treat these problems have been obtained.

Results include further development of the mixed spectral and coordinate method (SC method first published by us in 1985) for both scalar and electromagnetic problems. For the scalar case we have used this method to generate algorithms which are used to reconstruct rough surfaces from scattered field data. Two versions of the reconstruction are possible. The first is valid for small roughness and is FFT based. It reconstructs the profile using fixed frequency and fixed illumination angle data for the Dirichlet boundary condition. The second is valid in the domain of the Kirchhoff approximation and is FFT based, but here on a proscribed data set involving both incident and scattered angles. For larger roughness surfaces we have observed enhancement effects using a different numerical approach.

Final Report on Proposal: Backscattering Enhancement from Rough Surfaces (DAALO3-89-K-0024)

Author: Dr. John A. DeSanto

4A. Statement of the Problem Studied

General study of the field scattered from a rough surface. Specifically, the development of new models and new computational algorithms to investigate the behavior of this scattered field for very rough surfaces for which experimental evidence exists of an enhancement in the backscatter direction.

4B. Summary of the Most Important Results

We found the following results for the direct scattering problem using ensemble average results for homogeneous Gaussian distributed random surfaces for the Dirichlet boundary value problem. First, the coherent specular intensity is predominantly single scattering even when multiple scattering is occurring. Second, beyond a certain roughness the predominant field in the specular direction is incoherent rather than coherent. Third, the enhancement that occurs in backscatter also occurs in an interference-type term.

We found the following results for the inverse problem. It was possible to reconstruct rough surface profiles using scattered field data provided we stayed either in the perturbation theory domain or the Kirchhoff domain. In perturbation theory we used all the data (in all directions) to reconstruct the profile, using fixed frequency and fixed illumination angle. The reconstructions also worked as we narrowed the data window. The reconstruction algorithm is FFT based and is quite simple. For the Kirchhoff results we related the data to the surface profile using a Fourier transform relationship to a specific set of windowed data and again derived a different FFT based routine.

4C. List of Publications and Technical Reports

1. "Approximation Methods for Scattering from Rough Surfaces," Proceedings of the Second IMACS Symposium on Computational Acoustics (Princeton, March, 1989) in *Computational Acoustics*, vol. 2, eds. D. Lee, A. Cakmak, R. Vichnevetsky; Elsevier (1990), pp. 15-23.
2. "The Reconstruction of Shallow Rough-Surface Profiles from Scattered Field Data," *Inverse Problems*, **7**, L7-L12 (1991) (with R.J. Wombell).
3. "Rough Surface Scattering," Proceedings of the Conference on Directions in Electromagnetic Wave Modeling, Polytechnic Institute of New York, 1990 (with R.J. Wombell), in press.

4. "Rough Surface Scattering," *Waves in Random Media*, Proceedings of the Conference on Modern Analysis of Scattering Phenomena, Aix en Provence, France (1990), submitted (with R.J. Wombell).
5. "The Reconstruction of Rough-Surface Profiles Using the Kirchhoff Approximation," *J. Opt. Soc. Am. A*, submitted (with R.J. Wombell).
6. "k-Space Properties of Single- and Double-Layer Potentials and their Derivatives," *J. Phys. A: Math. and Gen.*(submitted).
7. "Coherent and Incoherent Scattering from Rough-Surfaces," J. Acoust. Soc. Am., submitted (with R.J. Wombell).

4D. List of All Participating Scientific Personnel

1. Dr. John A. DeSanto, principal investigator
2. Dr. Richard J. Wombell, postdoctoral research fellow